

What is claimed is:

1. A crucible for use in the single-crystal growth of aluminum-nitride, said crucible comprising:
 - a wall structure defining an interior crystal growth cavity;
 - said wall structure including a plurality of grains;
 - said grains being configured to swell due to absorption of at least one of aluminum and nitrogen;
 - said grains forming at least first and second layers, said first layer including grains forming an inside surface of said crucible and said second layer being superimposed with said first layer;
 - said layers including diffusion pathways defined by boundaries between adjacent grains; and
 - wherein diffusion pathways of said first layer are substantially obstructed by swollen grains of said second layer.
2. A sealable crucible for growing a III-nitride semiconductor crystal, said crucible comprising:
 - an elongated wall structure extending in a longitudinal direction;
 - said wall structure defining an interior crystal growth cavity;
 - said wall structure including a plurality of grains; and
 - said wall structure having a thickness dimension extending in a direction substantially perpendicular to said longitudinal direction, said thickness dimension being at least about 1.5 times the average grain size.
3. The crucible of claim 2 wherein said III-nitride semiconductor crystal is an aluminum nitride crystal.
4. The crucible of claim 3 being sized and shaped for growing an aluminum nitride single crystal using a sublimation-recondensation technique.

5. The crucible of claim 2 wherein said grains form at least first and second layers, said first layer including grains forming an inside surface of said crucible and said second layer being adjacent said first layer.
6. The crucible of claim 2 wherein diffusion pathways defined by boundaries between adjacent grains are substantially obstructed by others of said grains.
7. The crucible of claim 6, wherein said grains are configured to swell due to absorption of atoms of said III-nitride.
8. The crucible of claim 7, wherein said diffusion pathways are substantially obstructed by swollen grains.
9. The crucible of claim 2 wherein said cavity includes a substantially cylindrical portion and a tapered conical end portion.
10. The crucible of claim 2 wherein said wall structure defines a cavity having a transverse dimension ranging from about 5 to about 50 millimeters.
11. The crucible of claim 2 wherein said wall structure defines a cavity having a transverse dimension greater than about 50 millimeters.
12. The crucible of claim 2 wherein said thickness dimension is at least about three times that of the average grain diameter.
13. The crucible of claim 2 comprising a material selected from the group consisting of: tungsten-rhenium (W-Re) alloys; rhenium (Re); tantalum monocarbide (TaC); tantalum nitride (Ta₂N); hafnium nitride (HfN); a mixture tungsten and tantalum (W-Ta); tungsten (W); and combinations thereof.
14. A sealable crucible for growing a III-nitride semiconductor crystal, said crucible comprising:
 - an elongated wall structure extending in a longitudinal direction;

said wall structure defining an interior crystal growth cavity;
said wall structure including a plurality of grains; and
said grains forming at least first and second layers, said first layer including grains forming an inside surface of said crucible and said second layer being superposed with said first layer.

15. The crucible of claim 14 wherein diffusion pathways defined by boundaries between adjacent grains in said first layer are substantially obstructed by grains in said second layer.

16. The crucible of claim 15, wherein said grains are configured to swell due to absorption of atoms of said III-nitride.

17. The crucible of claim 16, wherein said diffusion pathways in said first layer are substantially obstructed by swollen grains in said second layer.

18. The crucible of claim 14, comprising a material selected from the group consisting of: tungsten-rhenium (W-Re) alloys; rhenium (Re); tantalum monocarbide (TaC); tantalum nitride (Ta₂N); hafnium nitride (HfN); a mixture of tungsten and tantalum (W-Ta); tungsten (W); and combinations thereof.

19. A method for fabricating a crucible for use in growing aluminum nitride single crystals, said method comprising:

fabricating an elongated wall structure from a granular material;
the wall structure defining an interior crystal growth cavity and including a plurality of grains;
wherein said grains form at least first and second layers, the first layer including grains forming an inside surface of the crucible and the second layer being superposed with the first layer.

20. The method of claim 19, wherein the granular material is selected from the group consisting of: tungsten-rhenium (W-Re) alloys; rhenium (Re); tantalum

monocarbide (TaC); tantalum nitride (Ta₂N); hafnium nitride (HfN); a mixture of tungsten and tantalum (W-Ta); tungsten (W); and combinations thereof.

21. The method of claim 19, comprising fabricating the wall portion by:
pressing the granular material into a desired size and shape;
sintering the granular material to form a sintered crucible;
heating the sintered crucible under conditions suitable to effect grain swelling;
wherein said heating is effected at at least about 2000 °C; and
wherein said heating is effected at or below about 2500 °C.
22. The method of claim 21, wherein said heating comprises heating in an atmosphere selected from the group consisting of inert atmospheres and chemically active atmospheres.
23. The method of claim 19, comprising fabricating the wall portion by:
mixing TaC powder and Ta₂C powder to form a mixture;
pressing the mixture into a desired size and shape;
sintering the mixture to form a sintered crucible;
heating the sintered crucible in CH₄, C₂H₂, or other hydrocarbon gas;
wherein the heating is effected at at least about 2000 °C;
wherein the heating is effected at or below about 2500 °C; and
wherein Ta₂C is converted to TaC.
24. The method of claim 23, wherein said mixing comprises mixing TaC with:
at least about 10 volume percent Ta₂C; and
up to about 50 volume percent Ta₂C.
25. The method of claim 23, wherein said mixing further comprises adding Ta to the mixture.
26. The method of claim 19, comprising fabricating the wall portion by:
mixing Ta₂N powder and Ta powder to form a mixture;

pressing the mixture into a desired size and shape;
sintering the mixture to form a sintered crucible;
heating the sintered crucible in about 0.1 to 10 bars of N₂ gas;
wherein the heating is effected at at least about 2000 °C;
wherein the heating is effected at or below about 2500 °C; and
wherein Ta is converted to Ta₂N.

27. The method of claim 19, comprising fabricating the wall portion by:
mixing HfN powder and hafnium (Hf) powder to form a mixture;
pressing the mixture into a desired size and shape;
sintering the mixture to form a sintered crucible;
heating the sintered crucible in about 0.1 to 10 bars of N₂ gas;
wherein the heating is effected at at least about 2000 °C;
wherein the heating is effected at or below about 2500 °C; and
wherein Hf is converted to HfN.
28. The method of claim 19, comprising fabricating the wall portion by:
mixing W powder and Ta powder to form a mixture;
pressing the mixture into a desired size and shape;
sintering the mixture to form a sintered crucible;
heating the sintered crucible in about 0.1 to 10 bars of N₂ gas;
wherein the heating is effected at at least about 2000 °C;
wherein the heating is effected at or below about 2500 °C; and
wherein Ta is converted to Ta₂N.
29. The method of claim 28, wherein said mixing comprises mixing W with:
at least about 0.5 atom volume percent Ta; and
up to about 10 atom percent Ta.
30. A method for fabricating an aluminum nitride crystal, said method comprising:
depositing aluminum nitride in a crystal growth cavity of a crucible having an
elongated wall structure, the wall structure defining an interior crystal growth cavity and

including a plurality of grains, the grains forming at least first and second layers, the first layer including grains forming an inside surface of the crucible and the second layer being superposed with the first layer;

sealing the crucible;

heating at least a portion of the crucible to a temperature in excess of about 2000 degrees C.

31. The method of claim 30 comprising enabling grains of at least the second layer to swell, the swelling substantially blocking diffusion of aluminum along diffusion pathways defined by boundaries between grains of at least the first layer.